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War Bread—Corn Starch and High Protein Flour Mixtures for Baking.

L. E. Sayre.

Under present-day conditions, with large areas unproductive through the ravages of war, and a shortage of cereal crops in other localities, the question of bread production is a most serious one. In America we have depended largely upon wheat to supply this staple food. Corn, rye, and other grains have been used but sparingly, or only locally. In Europe white bread is almost unknown. Potato starch, rice flour, barley flour, corn meal, and other substitutes are being mixed with their bread. In Great Britain, under present laws, this mixture ranges from twenty to fifty per cent. This situation is bringing home to America the necessity for radically changing her diet. If each American will use for food during the year 1918 not less than two bushels of corn, this will release 200 million bushels of wheat, which, with the surplus already available, will allow us to export to Europe over 300 million bushels. This will win the war.

Corn has always been the staple article for bread making in certain sections of our country. Of late it is finding more and more favor as a food stuff. It is replacing wheat as the source of other commercial products, as well as adding other food stuffs to our dietary. Formerly starch was made entirely from wheat and potatoes. In every pharmacopœia in the world, except that of the United States, wheat starch is official. So it was here in the United States until 1890, when corn starch was made to take the place of wheat starch, and the former became recognized for the first time as official. Other corn products which may be mentioned in this connection are corn syrup and corn oil. The former is well established in our dietary, while the latter is destined to form a most important addition thereto.

Investigators have recently attacked the question of our bread supply in the light of these conditions, and have turned their attention to various substitutes for wheat flour and to mixtures of wheat and other flours. The question as stated in an article by Prof. E. H. S. Bailey is, "Do these substitutes fully take the place of wheat, and would it be wise for us to adopt their use in the interest of economy?" He then refers to the use of potatoes in food flour. He says: "If we compare dried wheat and dried potatoes, *i. e.*, the products when all the water is eliminated, we find the wheat is three times as rich in proteins as potatoes. On this account, when we diminish the wheat content in bread, we lower the protein content. In other words, we lower the content of the food which furnishes energy." Doctor Bailey also refers to the suggestion of others that corn flour might well be substituted for wheat when the latter is scarce. He remarks that "to a certain extent this is true, but here again is a product not so well adapted for bread making unless used with other cereals when bread is raised by means of yeast. Corn is not lacking in proteins and contains in addition a relatively large percentage of fat. The attitude of the government has thus far been against the use of mixed flours, or those which contain rye or corn

mixed with wheat flour. This has largely been because there was a chance for adulteration of wheat flour if the practice were allowed. Many flours are, of course, used as ready-to-cook pancake flours, etc., but the small tax and the regulations imposed have prevented any adulteration of wheat flour."

It is important to make clear in this paper that "corn flour" is a different article from that which is frequently used in the baking of biscuits and other articles of that kind, known as a cornstarch flour. Corn flour, we learn, is a product of the hominy industry and is the corn kernel ground with only a part of the hulls and the germ removed in a dry process. Therefore, corn flour contains about seven per cent of protein and a considerable amount of cellulose, while the cornstarch flour contains no protein, practically, and no cellulose. Cornstarch flour now on the market is claimed to be superior in food value to corn flour, as the former contains none of the indigestible fiber.

The gluten of corn has none of the rising qualities so characteristic of wheat gluten, hence it is of no particular value in bread baking, and for that purpose may be rejected. Starch flour is rendered more digestible by heat. This is especially valuable when bread is toasted. It is to be noted that we eat bread for its energy-giving qualities, its starch content contributes to this end. We turn to milk, eggs, meat, beans, etc., for proteins. Among the experienced bakers corn starch has become popular and its popularity is increasing. Its cost is from two to three dollars per barrel less than wheat flour; reduces shortening and sugar bills, increases the yield of bread, and our experiments have shown that from 10 to 40 per cent can be added to wheat flour in the making of bread, crackers and sweet goods. It becomes a matter of practical interest, therefore, to study its merits. Our own experiments in laboratory and kitchen have been confined to bread mainly in the utilization of the mixtures above noted. We have found that a high protein flour of 14 per cent and the corn starch mixed in the proportion of 33⅓ of the latter and 66⅔ of the former gives a loaf which is larger and, in every respect, an improved bread loaf—superior to that of bread from pure flour alone.

A tabulated statement of the results of the four varieties of loaves is appended. The process of manipulation as performed in the food laboratory by Mr. Lantz, under our direction, is also given.

RESULTS.

Loaf.	Weight of dough.	Weight of loaf.	Loss in weight.	Volume of loaf.
1	389.0 gms.	373.2 gms.	15.8 gms.	1,090 cc.
2	384.0 gms.	364.8 gms.	19.2 gms.	895 cc.
3	396.5 gms.	372.5 gms.	24.0 gms.	1,130 cc.
4	390.9 gms.	376.7 gms.	20.0 gms.	960 cc.

METHOD USED.

Warm the flour to 33° C. Dissolve the sugar, yeast, and salt in water (about 90 cc.) at 32° C. Pour this solution over about half of the flour and mix thoroughly into a sponge. Put sponge into an oven at 32° C. and let rise for 45 minutes. Mix in the remainder of the flour, knead for about five minutes, put into the 35° oven, and let rise for 15 minutes. Again remove from oven, knead for about five minutes, put back into

35° C. oven and let rise for 15 minutes. Again remove from oven, knead for about five minutes, but back into 35° C. oven and let rise for 65 minutes till the dough is at least twice as high as it was when put into oven. When put into the oven this last time the dough is placed into the greased pan and the top of the dough is greased. Bake for 35 minutes at an average temperature of 195° C. Average time total for this method, 3 hours and 30 minutes.

RECIPE USED.

14 per cent protein flour (pure or mixed with corn starch)	240 gms.
Sugar	11 gms.
Fleischmann's Compressed Yeast	7 gms.
Salt	3 gms.
Water (68 per cent)	164 cc.

Second series of tests, comparing mixtures of corn starch flour with 14 per cent protein flour and 11 per cent protein flour.

Loaf number, and composition.	Weight of dough.	Weight of loaf.	Loss in weight.	Volume of loaf
1. 25% corn starch and 75% of 14% protein flour	463.2 gms.	441.0 gms.	22.2 gms.	1,140 cc.
2. 33⅓% corn starch and 66⅔% of 14% protein flour	421.3 gms.	397.8 gms.	23.6 gms.	1,045 cc.
3. 25% corn starch and 75% of 11% protein flour	414.0 gms.	395.5 gms.	18.5 gms.	1,095 cc.
4. 33⅓% corn starch and 66⅔% of 11% protein flour	427.2 gms.	408.7 gms.	18.5 gms.	1,110 cc.

The recipe was the same as the above with the exception that the water used was regulated to suit each loaf. The following is the respective amounts of water used:

Loaf No. 1, 180 cc.; loaf No. 2, 168 cc.; loaf No. 3, 163 cc.; loaf No. 4, 163 cc.

The method was the same as the one previously employed with the following exceptions:

(1) 100 cc. of water, was added to make the sponge instead of 90 cc.
(2) The oven for the sponge was kept at 40°–42° C. instead of 35° C.
(3) The sponge was let rise 30-35 minutes instead of 45 minutes.
(4) The temperature at which the bread was baked was 180°-210° C. or an average of 195° C.
(5) Each loaf was baked for 30 minutes instead of 35 minutes.
(6) The time required for each loaf to rise to proper height in the pan the last time before putting into the oven to bake was as follows: Loaf No. 1, 1 hr. 40 min.; loaf No. 2, 1 hr. 42 min.; loaf No. 3, 1 hr. 53 min.; loaf No. 4, 1 hr. 46 min.
(7) Total time required in this process, less than 4 hours.
(8) By mistake an excess of water (above the 180 cc. required) was added to loaf No. 1 and this accounts for its larger volume and greater weight.

I have been permitted to use in this article a formula for bread which has been used in large batches for bakers' bread, and which contains about 10 per cent of corn starch. The following is the formula:

3 gallons water.
¾ lbs. C sugar.
½ lbs. corn oil.
33 lbs. flour.
3 lbs. corn starch.
6–8 oz. yeast.
3–5 hour dough; 27–35 minutes in proof box.

This dough should go to the oven when it is one-half inch from the top of the pan, so it will give a nice bloom in oven and will stand 5–6 degrees more heat.

By using corn starch and carrying out the above directions, this bread will be sealed from the outside and will retain the moisture longer than H. O. S. or corn flour and will not shrink.

I have had submitted to me various formulæ for the use of flour in making various kinds of crackers, vanilla wafers, graham crackers and other cakes. In these formulæ corn oil is used in place of other shortening material. This accounts for my interest in baking flour mixtures. Reports on these mixtures cannot be given at this time, but I am inclined to the opinion that the use of corn starch flour and a high protein flour in connection with corn oil for shortening and the other usual constituents, has a merit worthy of study. Attention should be called to the above table where it will be noted that No. 2 and No. 4 loaves fell when put into the oven. This undoubtedly was due to the fact that there was some fault in the application of heat or in the regulation of the same. In my experiments with these mixtures I have had, to say the least, splendid results.

During the past year mixtures of various percentages of corn starch and high protein (14 per cent) wheat flour have been sent to a number of housekeepers asking for their opinion of the bread which would result from the baking by the ordinary kitchen methods. In every case very favorable reports have been received, some of these stating that the bread was more palatable and nutritious than the ordinary bread made from patent wheat flour.

In connection with the interesting subject of the baking qualities of different flours, it may not be out of place to refer to what others, high in authority, have to say, gleaned from published articles and through personal correspondence.

The statement is made by I. S. Chamberlain (U. S. Department of Agriculture, Bureau of Chemistry, Bull. 81, 1904) that bread made with a flour whose gluten contains as little as 20 per cent glutenin rises well during fermentation, but flattens in baking. If it contains as much as 34 per cent glutenin the dough neither rises during fermentation nor in the oven. Variation of 2 per cent in glutenin gives rise to differences in bread which are quite recognizable to the expert baker. J. T. Willard and C. O. Swanson (Kansas Agricultural Experiment Station Bull. 177, 1911) state that in comparing flours of the same class there is no correspondence in the relation of the percentage of gliadin in the protein to the baking qualities of flour, but there is a comparing of flours of different class. Baking qualities depend as much on physical properties of flour as upon the percentage of protein or gliadin.

In correspondence with Professor Swanson, I learn from him that he does not think that the percentage of protein or gliadin by themselves are determining factors. The percentage of protein is an indication of the amount of gluten in the flour, but tells nothing about the quality of this gluten, and quality is more important than quantity. Neither does he think that the relative percentage of gliadin and glutenin is a determining

factor. Two flours may have the same percentage of alcohol-soluble protein, but differ very greatly in baking qualities. In a series of mill stream flours, all made from the same wheat, the percentage of gliadin will be higher in the better grades, but this is as far as the comparison goes, so far as he knew.

Professor Swanson thinks we shall have to work out the baking factors separately. For instance, a certain set of factors controls the absorptive capacity. Another set of factors controls loaf volume, another what we may call adaptability for a variety of purposes. Then the problem is complicated by the fact that the same factor may enter into several of the characteristics. He thinks that no progress will be made upon these lines until we take up some of the fundamental problems. The development of collodial chemistry ought to be a great help. The electrolytes are possibly of more fundamental importance than we have thought.

However well a flour may be adapted for bread baking, so far as physical qualities are concerned, its value in our dietary will depend entirely upon the digestibility of the finished product. Accordingly experiments have been made as to the comparative digestibility of breads, using artificial digestion. The results show that one bread is as digestible as the other—that of wheat flour alone, and that of the corn starch mixture. It may be in place to state that any experiments, however modest they may be, which contribute to the subject of wheat conservation at this time, are of interest, and if these point only to a line of work which others more competent and better equipped may follow up to some definite and practical conclusion, it would help to further the solution of the problem of food conservation.

Recent experiments on nutrition have more clearly than ever emphasized the importance of mixed diet, and because of the bearing these have it may be well to give a brief review of some of them in so far as they may touch upon the subject in hand. In the first place, it may be stated that dieticians are now making some fine distinctions as to what is efficient and what is comparatively inert as food material, and we are more than interested in watching how these fine distinctions are employed. Furthermore, recent scientific investigations have shown that the proteins of different foods are not alike, nor have they the same degree of efficiency. Each food substance has what may be termed efficient and deficient proteins. The gelatine of meat may be regarded as a deficient protein, since it does not contain the full quota of amino-acids. Another example of deficient protein is gliadin of wheat; still another is zein of corn. All of these protein substances, however, yield nitrogen, and by computation may show protein values, which may be misleading. The fact seems to be that laboratory analysis is no indication of the real merit of proteins. An examination of foods in the chemical laboratory does not tell anything at all about their actual nutritive values. The same ambiguity arises in feeding; if, for example, corn is fed with oats, the results are better than if each were fed alone.

We occasionally find a rather misleading comparison made between the value of the protein of wheat and that of corn, by comparing inefficient zein with the glutelin of wheat. Although maize protein contains zein in a large amount, the next most abundant protein, glutelin, of

corn, has been shown to yield all the amino-acids which zein lacks, and as it is probable that the remaining proteins likewise yield them, the amino-acid efficiency of zein is thus more or less supplemented when the entire feed is fed. (Osborn and Mendel, Journal of Biological Chemistry, Vol. 18, No. 1.)

Doctor Osborn (American Journal of Physiology, Vol. 20, p. 447) states: "It is interesting, however, to note that these amino-acids, which are lacking in zein, are all present in notable proportions in this (alkali-soluble) protein, so that the mixture of the proteins as they occur in this seed (maize) yields all the amino-acids usually obtained from protein substances." Of late, corn proteins have been criticised for the lack of lysine, which wheat gluten contains. However, Dr. E. V. McCollum (Journal of Biological Chemistry, Vol. 18, No. 2, 1917) found conclusively through feeding experiments that lysine is not the limiting factor which determines the biological value of the corn proteins. In fact, he found that in certain instances the protein which does not yield lysine serves to enhance the value of certain proteins. As stated before, a mere chemical examination of foods does not throw much light upon their actual nutritive values; and when mixtures are fed, the nutrition problem is, in proportion, difficult of solution.

If the whole wheat plant alone forms the sole ration for animals, disastrous results occur. The same is true to a less extent if the corn plant forms the sole ration. This is true also with other grains. In the all-wheat ration malnutrition sets in, caused not only by deficient protein, but also through poisonous substances found in the germ. (Hart, Miller and McCollum, Journal of Biological Chemistry, Vol. 25, June, 1916.)

We find the proteins of corn are 40 per cent efficient, for milk production, while wheat proteins are only 35 per cent. Considering the efficiency of proteins for growth, McCollum found that corn alone was nearly 30 per cent, while wheat alone was only 15 per cent. He also found that young rats cannot grow more than about half as fast as they should on good diet, if their ration contains a low wheat protein content of poor quality. All this shows that it is unwise to have one grain predominate in a ration for man or animals, but each grain supplements the other to more or less extent, and each is benefited by the other. In other words, a combination of two grains is always better than each by itself. It is foolish to condemn one grain, and prefer another. Each has its place in our diet, and there is room for all.

In the series of experiments which I have conducted to determine the digestibility of bread made from mixtures of wheat flour and corn starch, the following procedure was employed: Three samples of bread were selected. No. 1 represented a bread made from a mixture of 66⅔ per cent high protein, 14 per cent flour and 33⅓ per cent corn starch. No. 2 represented a bread made from Bowersock's "Zephyr" flour, which is a high patent flour made from Kansas hard wheat. This bread was made in one of the homes and is that which is commonly called "home-made" bread. No. 3 was a sample of "baker's" bread, such as is served in hotels and restaurants.

The three bread samples were simultaneously heated in an oven at 110° C. for a period of thirty minutes. This treatment rendered the bread dry and friable and easily pulverized. One-gram samples (in duplicate of each bread) were taken for the digestion experiments and treated as follows:

In the salivary digestion each sample of the dried and pulverized material was treated with 10 cc. saliva (1-10 aqueous solution) and digestion was carried on for one hour at 37° C. At the end of this period the digestion mixtures were filtered through tared filter papers and the residues, after being allowed to dry spontaneously and later at 110° C. for one hour in a hot-air oven, were weighed. The weights of the residues were as tabulated below:

I	0.456 gms.
I* (duplicate)	0.495 gms.
II	0.465 gms.
II*	0.484 gms.
III	0.365 gms.
III*	0.394 gms.

These residues were then treated with 100 cc. of a pepsin solution (1 gm. scale pepsin dissolved in 100 cc. N/10 HCl). This digestion was carried on for six hours in a 37.5° C. incubator. At the end of this period the digestion mixtures were filtered through tared hard filters as in the previous experiment with salivary digestion. The residues were dried and heated at 110° C. for one hour in a hot-air oven and then weighed. The weights of the respective residues were as tabulated below:

I	0.150 gms.
I*	0.119 gms.
II	0.205 gms.
II*	0.334 gms.
III	0.180 gms.
III*	0.155 gms.

These second residues were then subjected to pancreatic digestion for six hours at 37.5° C. The pancreatic fluid was made by dissolving 1 gm. of Merck's pancreatin in 100 cc. of 1 per cent $NaHCO_3$ solution. Each residue was treated with 50 cc. of the pancreatic fluid. At the end of the digestion period the mixtures were filtered through tared filters, allowed to dry and later heated at 110° C. for one hour in the hot-air oven. The residues were then weighed and compared as per tabulation below:

I	0.075 gms.
I*	0.068 gms.
II	0.143 gms.
II*	0.125 gms.
III	0.095 gms.
III*	0.079 gms.

Summary and Interpretation of Results.

It will be seen from the above that in the first amylotic digestion that the following percentages of digested material were produced:

I	1 gm. — 0.456 = 0.544 gm., or 54.4%
I*	1 gm. — 0.495 = 0.505 gm., or 50.5%
II	1 gm. — 0.465 = 0.535 gm., or 53.5%
II*	1 gm. — 0.484 = 0.516 gm., or 51.6%
III	1 gm. — 0.365 = 0.635 gm., or 63.5%
III*	1 gm. — 0.394 = 0.606 gm., or 60.6%

In the second experiment, or gastric digestion, the following percentages of proteolytic digestion products were produced:

I	0.465 gm. — 0.150 = 0.306 gm., or 30.6%
I*	0.495 gm. — 0.119 = 0.376 gm., or 37.6%
II	0.465 gm. — 0.205 = 0.260 gm., or 26.0%
II*	0.484 gm. — 0.334 = 0.150 gm., or 15.0%
III	0.365 gm. — 0.180 = 0.185 gm., or 18.5%
III*	0.394 gm. — 0.155 = 0.239 gm., or 29.3%

In the third experiment, pancreatic digestion, the following percentages of pancreatic peptones and soluble products of digestion were produced:

I	0.150 gm. — 0.075 = 0.075 gm., or 7.5%
I*	0.119 gm. — 0.068 = 0.051 gm., or 5.1%
II	0.205 gm. — 0.205 = 0.143 gm., or 6.2%
II*	0.334 gm. — 0.125 = 0.109 gm., or 10.9%
III	0.180 gm. — 0.095 = 0.085 gm., or 8.5%
III*	0.155 gm. — 0.079 = 0.076 gm., or 7.6%

From the data obtained above the total soluble digested products were calculated and found to be as follows:

I	92.85%
II	81.15%
III	91.30%

It would therefore be inferred from this data that the order of digestibility of the various breads would be as follows:

1. Bread made from a mixed flour composed of 66⅔ per cent high protein flour and 33⅓ per cent corn starch.
2. Baker's bread (the exact composition of this bread was not learned).
3. "Home-made" bread, made from a high patent Kansas hard wheat flour.

The manufacturers are constantly striving to improve their products and adapt them more thoroughly to the conditions which confront us to-day. Since these studies were begun a product has been announced which is claimed to be superior to the corn flour already used. This new product is called "corn gluten flour." The manufacturers say that it "contains about 7 per cent of protein, 1 per cent of oil, the balance starch. It does not contain any fiber. We consider this latter fact a decided advantage, since it makes this product a truer substitute for patent wheat flour, which is practically fiberless. Other wheat substitutes contain from 1 per cent to 13 per cent fiber, which of course makes them less digestible."

Corn starch, when mixed with ordinary patent flours, furnishes as acceptable a loaf and in every way as satisfactory in lightness, porosity, calorific value as that of patent flour. The breads of the latter variety have been made in our Home Economics department.

The one property which the addition of corn starch seems to contribute is that of porosity. The patent flour seems to make a very fine and comparatively compact loaf, spongy and light. The greater addition of starch seems to contribute porosity. The crust of the bread of the corn starch mixtures does not brown as nicely as the patent flour, but gives a very light yellowish brown crust, which is very satisfactory. We have tried combinations of the high protein flour 50 per cent, corn starch 25 per cent, and corn meal 25 per cent, which makes a very nutritious loaf, and from many standpoints a more nutritious bread.

Price of Douglas Baker's Pure Food Corn Starch, $5.15 per hundredweight in bags, $5.20 in barrels, f. o. b. Kansas City.

Another phase of the investigations which have been instituted in the search for wheat substitutes has been the testing of various materials which have had a very limited use heretofore in bread making, as well as to inspire investigations of materials formerly considered waste products. In line with the former is an article in the American Food Journal for December, 1917, by Elizabeth C. Sprague and Ethel Loflin, of the home economics department of the University of Kansas. In this article the use of flour from rye, oats, barley, rice, and kafir corn are discussed. They conclude that "even with a considerable shortage of wheat there need be no shortage of bread, as long as we have a good supply of other cereals. It is evident that we must depend upon wheat in a large measure for the texture, lightness and flavor of our bread, but that wheat has no unique nutritive value. 'The demand for wheat bread represents a habit of mind and palata rather than any nonreplacable need.' The real and great need is the production of these flours on a commercial scale, their sale at a reasonable price, and their use not only in the homes but in bakeries. With the more refined methods of milling applied to these grains and the production of finer flours, larger proportions of each might be used. In the light of our present experience, we feel justified in advising the use of 25 per cent of any of these flours."

As an example of the search for wheat flour substitutes among what were formerly considered waste products, may be cited the article in the *Cracker Baker* for January, 1918, by H. Steinson, on "Coffee and Charcoal Biscuits and Coffee, Something New for the Progressive Biscuit Manufacturer." He says in part: "Just how much of the coffee flour should be used in a barrel of wheat flour would have to be determined by experimenting. The following recipe is suggestive, and may form the basis for some biscuit maker to take up the making of such biscuits. I see no reason why they should not become a staple article. The recipe or something similar will certainly make a palatable biscuit. I am told a coffee flour of good quality could be made and sold for fifteen to eighteen cents a pound. The biscuit maker will note that coffee flour costs less than the shortening, at present, and he knows he gets pound for pound of the coffee back, but not of the shortening used in a barrel of flour.

COFFEE BISCUITS.

Flour	198 lbs.
Coffee flour	30 lbs.
Yellow sugar	20 lbs.
Shortening	20 lbs.
Soda	1 lb.
Ammonia	1 lb.
Salt	2 lbs.
Honey	6 lbs.
Water (about)	40 lbs.

"The above made into a dough, is handled much the same as any other hard, sweet biscuit, such as arrowroot. The mixer should run well for an hour, and the baking of the dough should be proportionately well done. When so handled, the biscuits take on a fine, smooth finish, which receives and retains clear-cut impression and lettering."

An analysis of coffee grounds by us shows that they may be expected to be highly nutritious, as they contain crude fat 13.17 per cent, protein (N x 6.25) 11.84 per cent, fiber 28.22 per cent, and practically no sac-

charine material. Coffee grounds, if made into a powder as fine as flour, is worth experimenting with, since they contain as unexpectedly large percentage of fat and a like proportion of protein, and during the process of baking no caffein could remain should there be any unextracted alkaloids in them. Some crackers made by us and flavored with cinnamon or ginger have proven quite palatable. As to their value as a dietary, it will take some time to determine and give any satisfactory report.

Prices of corn starch flour January 10, 1917: 100 pounds (Chicago), $3.05; 100 pounds (Lawrence), $3.29.

From *Bakers Weekly*, December 2, 1916. File. Addenda to article for Kansas Academy of Science, January 12, 1917.

Determining the Strength of Flour.

PROF. T. B. WOOD, Cambridge University.

After seven years of investigation the author has worked out the following theory on the strength of wheat flours, which has finally enabled him to devise a method which promises to be both accurate and rigid, and to require a very small amount of flour. The strength of a wheat may be defined as the power of making a large loaf of good shape and texture. Evidently strength is a complex of at least two factors, size and shape, which are likely to be quite independent of each other. Not infrequently, for instance, wheats are met with which make large loaves of bad shape or small loaves of good shape.

A FEASIBLE IDEA.

It seemed a feasible idea that the size of the loaf might depend on the volume of gas formed when the yeast was mixed with different flours. On mixing different flours with water and yeast it was found that for the first two or three hours they all gave off gas at about the same rate. The reason of this is that all flours contain about the same amount of sugar, approximately 1 per cent, so that at the beginning of the bread fermentation all flours provide the yeast with about the same amount of sugar for food. But this small amount of sugar is soon exhausted, and for its subsequent growth the yeast is dependent on the transformation of some of the starch of the flour into sugar. Wheat, like many other seeds, contains a ferment or enzyme called diatase, which has the power of changing starch into sugar, and the activity of this ferment varies greatly in different wheats. The more active the ferment in a flour, the more rapid the formation of sugar. Consequently the more rapid the yeast will grow, and the greater will be the volume of gas produced in the later stages of fermentation in the dough.

ESTIMATING THE SIZE.

From these facts it is quite easy to devise a method of estimating how large a loaf any given flour will produce. Twenty grams of flour are weighed out and put into a wide-mouthed bottle. A flask of water is warmed at 40° C. Of this, 100 cc. is measured out and into 2½ grams of compressed yeast is intimately mixed, 20 cc. of the mixture being added to the 20 grams of flour in the bottle. The flour and yeast water are then mixed into a cream by stirring with a glass rod. The